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THE BIOSATELLITE: RESULTS OF THE EXPERIMENT

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16. Abstract

Results of a 22 day biosatellite flight containing white mice, tortoises, insects, microorganisms and fungi, with duplicated conditions on an Earthbound control group to determine effects of weightlessness.

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THE BIOSATELLITE: RESULTS OF THE EXPERIMENT

O. Gazenko[1]

On 22 November 1973, after a 22 day long flight, the satellite Kosmos-605 with white mice, tortoises, insects, microorganisms and fungi located aboard made a landing on the Earth and delivered valuable scientific information.

Conducting experiments with biological objects aboard specialized unmanned spacecraft required creating an automatic apparatus providing for the normal vital activity of the animals as well as measuring and transmitting to the Earth data on their condition, environmental conditions, and the operation of the corresponding systems.

Each experimental animal (rat) was placed in a separate small compartment and was kept in the free (unfixed) state. Within the chamber were a feeding device, a watering device, lights, and a system of apertures for supplying air and constantly ventilating the interior of the chamber with a direct stream.

Each chamber was equipped with a special electronic measuring device which made it possible to consider and summarize the number of the animals' movements over a two hour time interval.

The tortoises, insects, microorganisms and fungi used in the experiments were placed in special containers providing for the appropriate conditions of habitation.

Supplying the animals with oxygen and purifying the atmosphere within the launched apparatus of excess carbon dioxide and other harmful gaseous impurities were accomplished by a system of chemical atmospheric regeneration. The temperature-humidity regime was maintained by a system of temperature regulation with an atmospheric drying device.

Simultaneously with the flight of the satellite, on the Earth a synchronized control of the experiment was carried out. For this purpose, a model of the launched apparatus with working equipment completely corresponding to the flight

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types were used. In this apparatus were placed the control groups of animals and other biological objects. Telemetry data obtained from the satellite were input to special systems which duplicated on the Earth the operating regime of the corresponding systems in flight.

All this made it possible to simulate on the Earth control animals' conditions similar to those of flight, except for weightlessness, so they could be monitored. As a result, materials were obtained for making a comparative analysis and a differential study of the effect of weightlessness. The physiological experiments with the steppe tortoises and rats make it possible to compare the reaction of the animals of a different level of organization to the effect of weightlessness. The use of a large number of specimens made it possible to obtain statistically reliable material.

Before flight the rats were carefully examined and underwent special training in order to accustom them to the conditions of staying in the on board apparatus of the satellite, to the characteristics of feeding, water supply, etc. After completing the flight, a comprehensive examination was once again conducted. All rats were divided into three groups. The first group, consisting of 20 experimental animals and the same number of control animals, after one day was subjected to a pathological-anatomical autopsy for studying the direct effect of weightlessness on the structure and function of cells and tissues of the organism. In the second group, of the 12 experimental and 12 control rats, the physiological investigations were conducted over a period of 25 days following the flight. Then, with the goal of studying the characteristics of the processes of adapting to the terrestrial gravitation after long term weightlessness, these animals were also subjected to pathological-anatomical autopsy and an investigation of tissues by electron microscopic, histochemical, and biochemical methods. One group of animals remained for studying the remote aftereffects of the flight-rate of aging, viability of descendants, etc.

Pathological-anatomical autopsy of six tortoises which were aboard the Kosmos-605 satellite was carried out 3, 15, and 30 days after terminating the flight. During the examination, the same methods were employed as in the experiment with the rats.

The investigations were conducted with the following basic directions: Conduct and higher nervous activity; structural and biochemical characteristics of different regions of the brain and spinal cord; metabolic processes at our level; endocrine glands, lymph organs; blood and processes of hemopoiesis; cardio-vascular system; skeleto-motor apparatus.

Recording the dynamics of the level of motor activity of the rats in flight demonstrated that their behavior under conditions of long term weightlessness was quite active. The degree of food use in flight was somewhat diminished in comparison with the preflight period and that of the terrestrial experiment.

During flight, the main increase in weight of one animal was 20 grams, while in the control experiment it was 80. Such a retardation in weight increase among animals at the stage of active growth indicates that long term weightlessness noticeably influences the course of metabolic processes.

Actually, in the post flight examination of the rats a decrease in the consumption of oxygen by 10 to 20 percent was detected; there was a decrease in body temperature; inhibition of processes of oxidative phosphorylation in the skeletal muscles; a change in the activity of certain enzymes in the heart tissues, skeletal muscles, liver, kidneys, and endocrine glands; there were certain signs of disruption of the lipid metabolism. Changes in the metabolic processes were also detected during the examination of the tortoises.

It was established as the result of chemical analysis that the total body content of salts in the animals did not significantly change. Moreover, under conditions of weightlessness a redistribution of salts apparently occurred. This is specifically indicated by a decrease in the mechanical resistance of the bones, on the average by 25 percent.

The behavior of the animals in the first day following return to the earth was characterized by slight listlessness and inhibition. This is apparently linked with general flight fatigue. With respect to long term and short term memory, it was unaltered. A long term stay under conditions of weightlessness also did not influence coordination of the rats' movement and their compacity for spatial orientation.

During the microscopic investigation of the peripheral blood of the rats, an increase in the number of eosinophils and a decrease in the number of lymphocytes and reticulocytes was established. Changes in the bone marrow hemopoiesis were manifested in a decrease in the total number of cells and suppression of the red cell production of the bone marrow.

At autopsy of the first group of animals, no pathological changes of the vitally active organs were found. Moreover, a decrease in the weight of the lymphoid organs attracted attention - the spleen and the thymus decreased in weight but there was a slight increase in weight of the adrenals. This can be viewed as a manifestation of the organisms' stress reaction to the combination of flight factors. Atrophy and a decrease in the electrical activity of the so-called "antigravitation" muscles of the posterior extremities of the rats were also detected. During the examination three to four weeks following the flight, most of the noted disorders were not observed. The animals were active, mobile and had gained weight well.

Today, the materials obtained in the course of the flight are being carefully analyzed and a study is being carried out of the process of adaptation to the terrestrial force gravity.

A detailed examination by a combination of modern cytochemical, biochemical and morphological methods make it possible to obtain information on the mechanism of the effect of long term weightlessness at the tissue and cellular levels. This, then, will make it possible more closely to approach an understanding of the mechanisms of functional changes which are observed during manned space flights.

The basic goal of the biological experiments aboard Kosmos-605 was to study the influence of long term weightlessness on processes of the organisms' development. For this purpose, drosophila, flour beetles, bacteria, and hyphomycetes were used.

A relatively simple experiment was set up with the drosophila aboard the biosatellite. Mated pairs were placed in test tubes such that one could easily distinguish the first generation of descendants by external appearance. In the material which was obtained after the flight, many specimens of the first

generation were observed and a few of the second generation. This means that drosophila produced practically normal descendants.

Certain males and females which developed in space also subsequently produced offspring. Hence, for the first time a second generation of animals which developed under conditions of weightlessness was obtained. No differences in morphology and the value of genetic information were detected between the parent generation and the descendants.

The flour beetle was placed aboard the satellite at different stages in its life cycle: egg, early larva, late larva, prepupa and pupa. The basic task of the experiment consisted in obtaining transition from the lower stage of development to the higher stage of development under conditions of weightlessness. The cycle of development passed normally. The viability of all specimens in all groups, in both the experiment and the control was nearly 100 percent.

For the first time in space biology, an experiment with hyphomycetes, which do not require photosynthesis for their development, was conducted aboard the Kosmos-605 satellite; at the same time, these fungi have a well-pronounced geotrophism, i.e., the influence of the force of terrestrial gravitation on the developmental processes. The results clearly showed how strongly weightlessness can influence the development of plants. Thus, among the fungi raised under conditions of weightlessness there was much poorer development of the supporting tissues, while the pedicel supporting the spore was much thicker and in area the fungus exceeds that of the "terrestrial varity".

In addition to the experiments performed on biological objects, investigations were conducted to solve problems of maintaining radiation safety of crews and equipment during long flights. Chief here was an experimental study of a new and promising type of radiation protection against the effects of charged particles--electrostatic protection. It is based upon creating and maintaining near the protective compartments an electrical field which deflects fluxes of charged particles and decreases the level of radiation within the protected compartment to permissible limits.

The measurements indicate the high "quality" of the space vacuum as an

insulator in electrostatic protection even at altitudes of 200-400 km, notwithstanding the large amount of charged and neutral particles there. Moreover, for the first time experimental confirmation of the possibility of automatic functioning of electrostatic protection within the radiation belts of the earth was obtained.

One can with certainty say that the conducted experiments made a new contribution to space biology.

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